



Armed Forces College of Medicine

AFCM



& Motor Cortex Cortical Control of Motor Function

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• **By the end of this lecture the student will be able to:**

- ✓ List the **cortical motor areas** (primary, premotor, supplementary), their characteristics, functions & the effects of their lesions.
- ✓ Explain the importance of the related cortical structures located within the motor area 6 & their specific functions.
- ✓ Describe Prefrontal association area and list its functions.
- ✓ Describe the cortical control over the motor function.
- ✓ Describe cortical plasticity.

Lecture Plan



1. Part 1 (5 min) **Introduction**
2. Part 2 (35 min) **Main lecture:**
 - 1. Cortical motor areas function and lesion**
 - 2. Cortical control over the motor function**
3. Part 3 (5 min) **Summary**
4. **Lecture Quiz** (5 min)

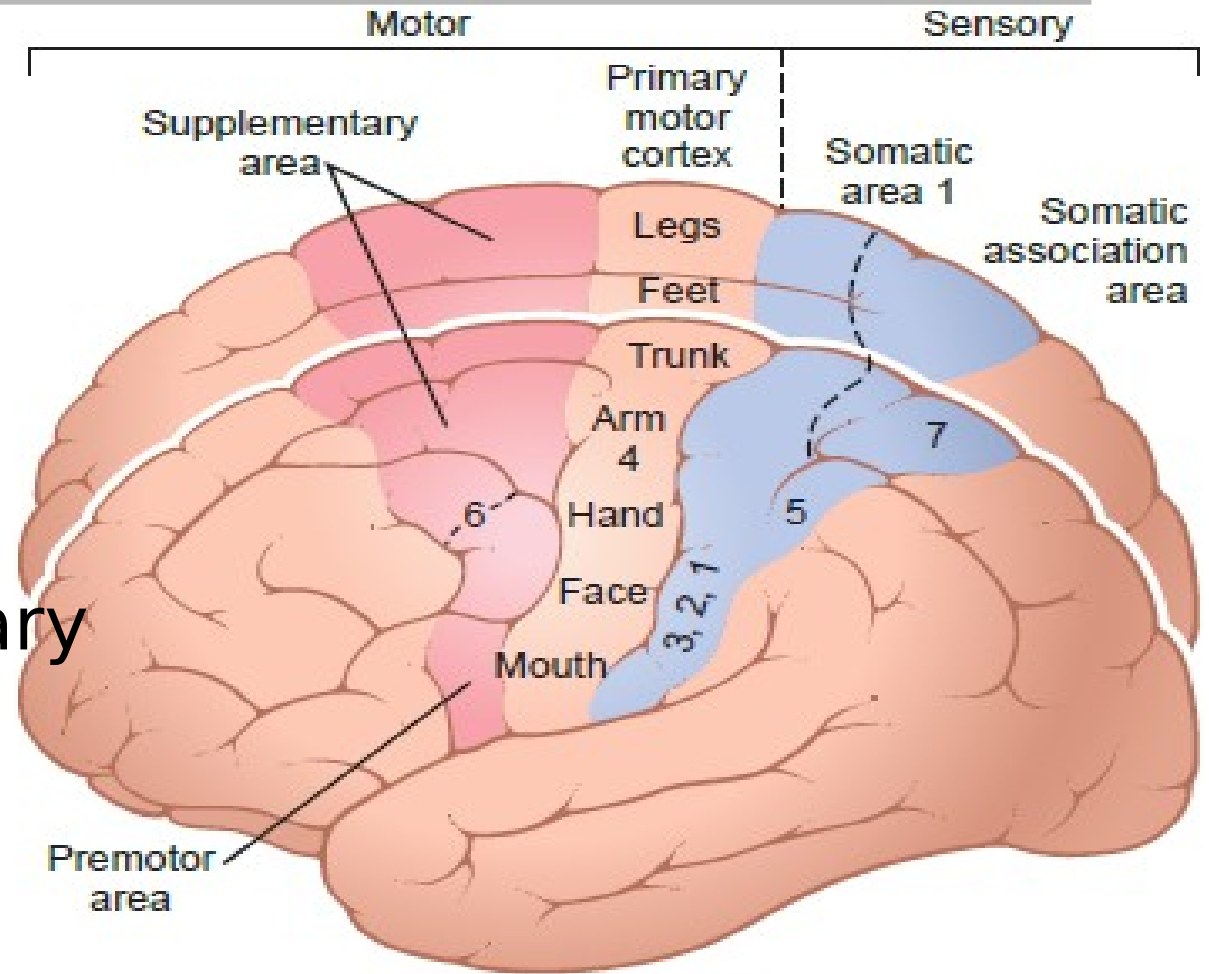
Cortical motor areas



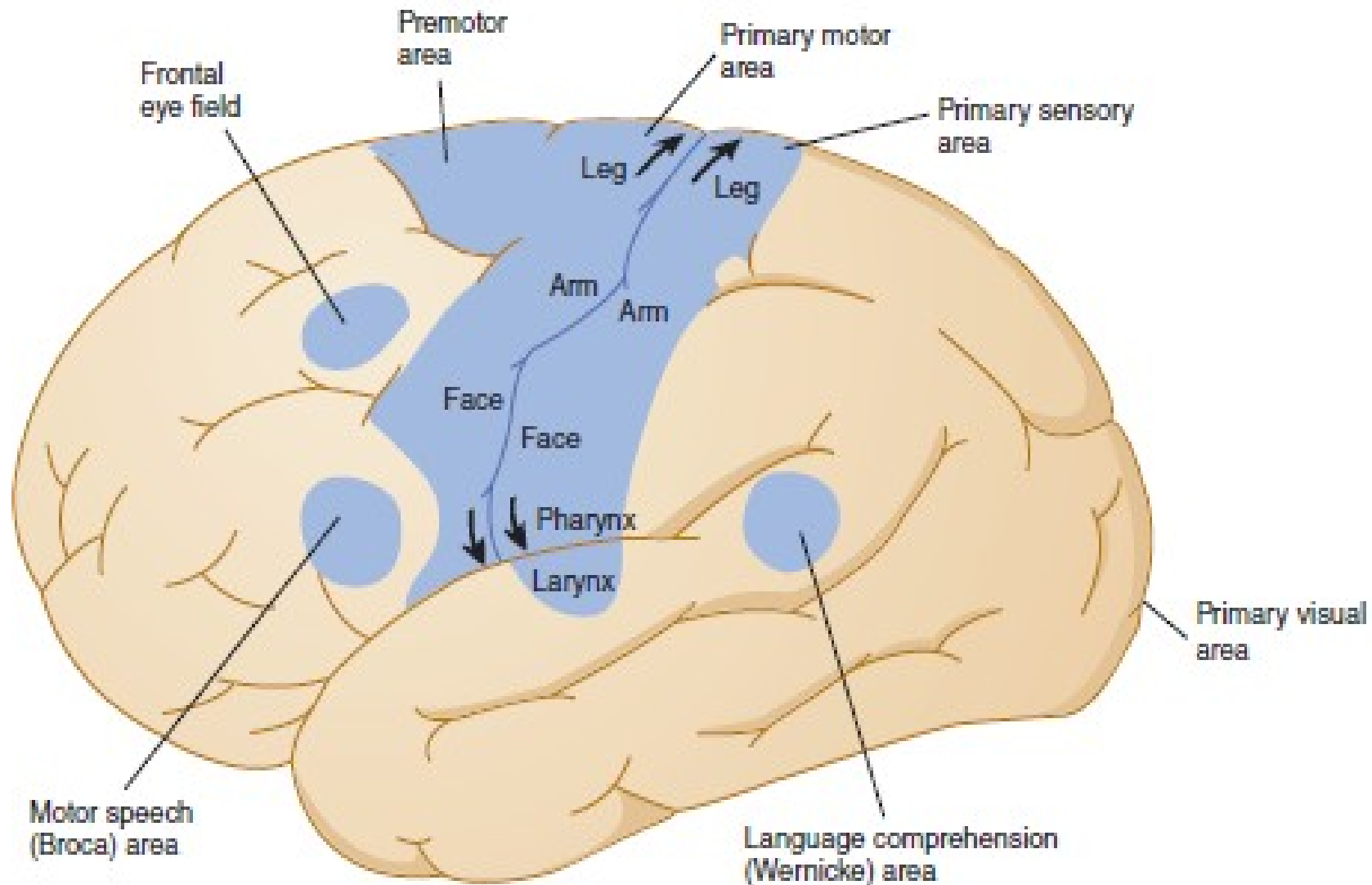
The 3 cortical motor areas are:

1. Motor area **4** = Primary motor area.
2. Motor area **6** = Premotor area.
3. **Medial area 6** = Supplementary motor area.

Central sulcus separates somatosensory cortical areas (Postcentral gyrus- parietal lobe), cortical motor areas (Precentral gyrus- frontal lobe)



Motor and somatosensory functional areas of the cerebral cortex. The numbers 4, 5, 6, and 7 are Brodmann's cortical areas. Guyton and Hall 13th ed.



A lateral view of the left hemisphere showing some principal cortical areas in the human brain.

The primary somatosensory area is in the postcentral gyrus of the parietal lobe, and the

Motor area 4: (primary motor cortex)



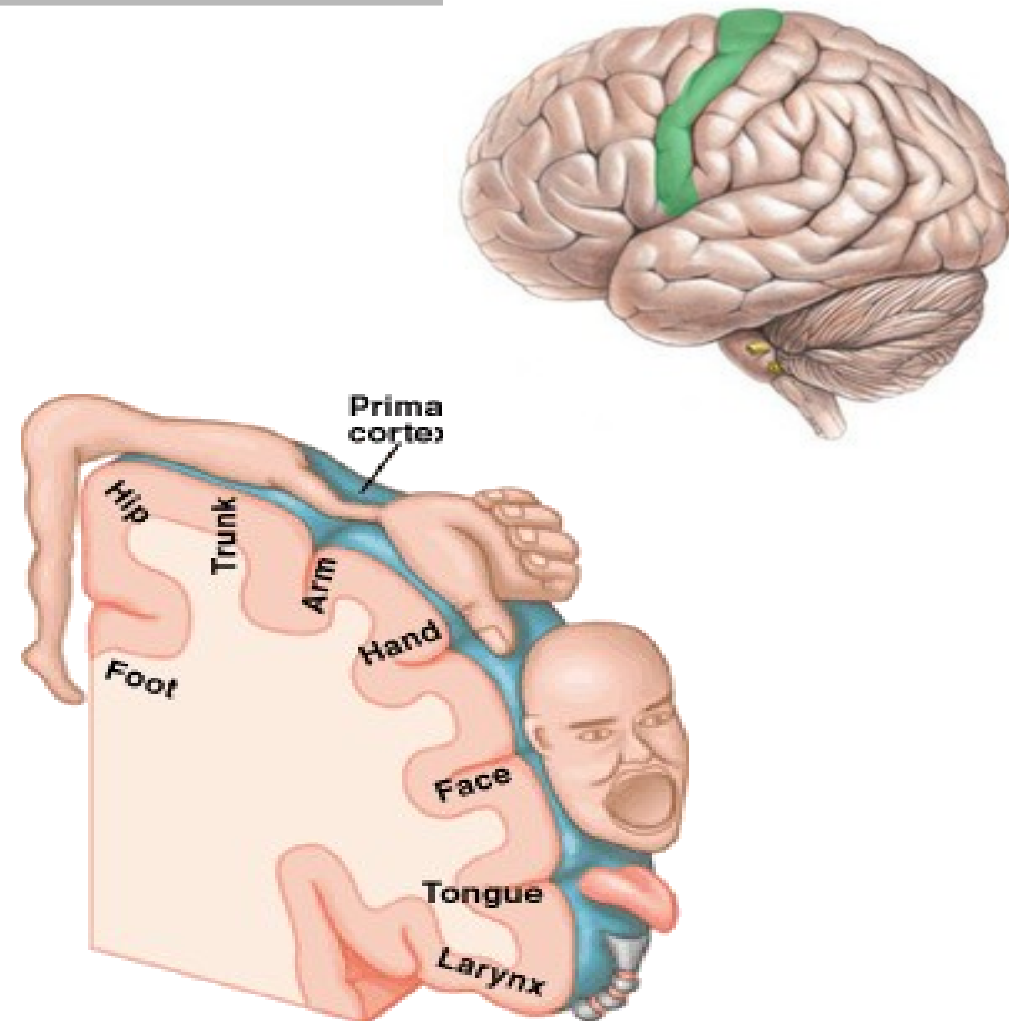
Site: Precentral gyrus in frontal lobe.

Topographical representation:

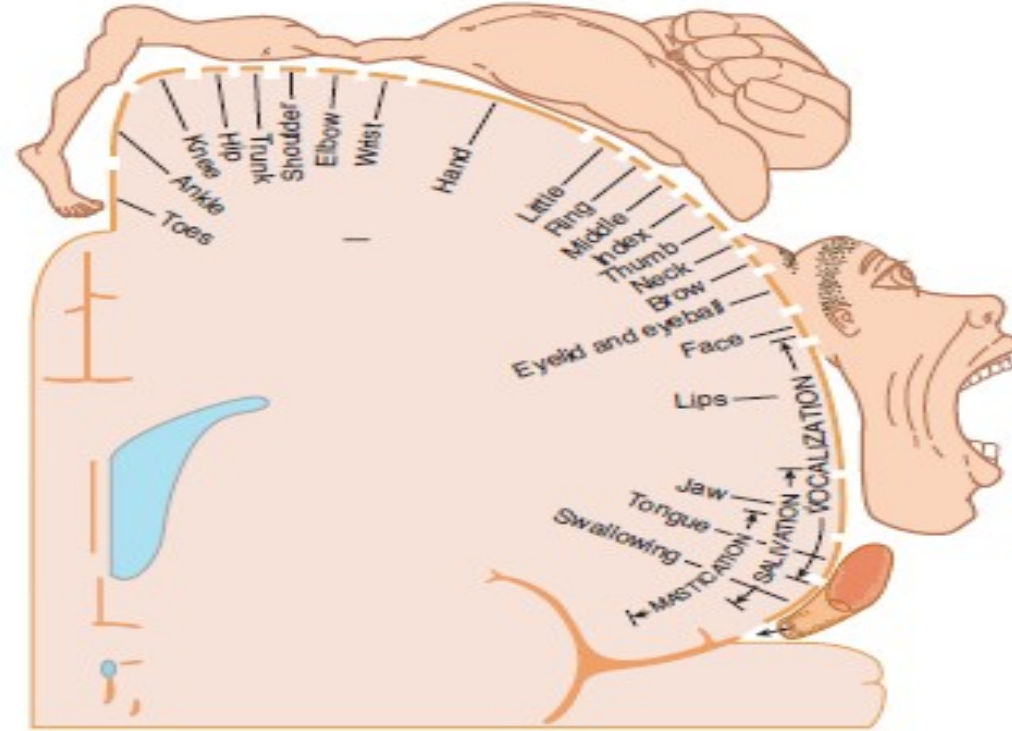
- **Inverted** (with the feet at the top of the gyrus and the face at the bottom).
- **Crossed** (The facial area is represented bilaterally(Upper???), but the rest of the representation is generally unilateral, with the cortical motor area controlling the musculature on the opposite side of the body).

- Area of representation is **proportional to the skilled movement produced**

(The areas involved in speech and hand movements are especially large in the cortex; use of the pharynx, lips, and tongue to form words and of the fingers and opposable thumbs to manipulate the environment are activities in



The motor homunculus in primary motor cortex.
<https://brainconnection.brainhq.com/2013/03/05/the-anatomy->



[https://
en.wikipedia.org/wiki/
File:Side-black.gif](https://en.wikipedia.org/wiki/File:Side-black.gif)

Motor homunculus with the feet at the top of the gyrus and the face at the bottom. Controlling the musculature on the opposite side of the body. The cortical representation of each body part is proportional in size to the skill with which the part is used in fine, voluntary movement.

Note that more than one half of the entire primary motor cortex is concerned with controlling the muscles of the hands and the muscles of speech.

(Reproduced with permission from Penfield W, Rasmussen G: *The Cerebral Cortex of Man*. Macmillan, 1950.) Ganong 25th

Motor area 4 : (primary motor cortex)



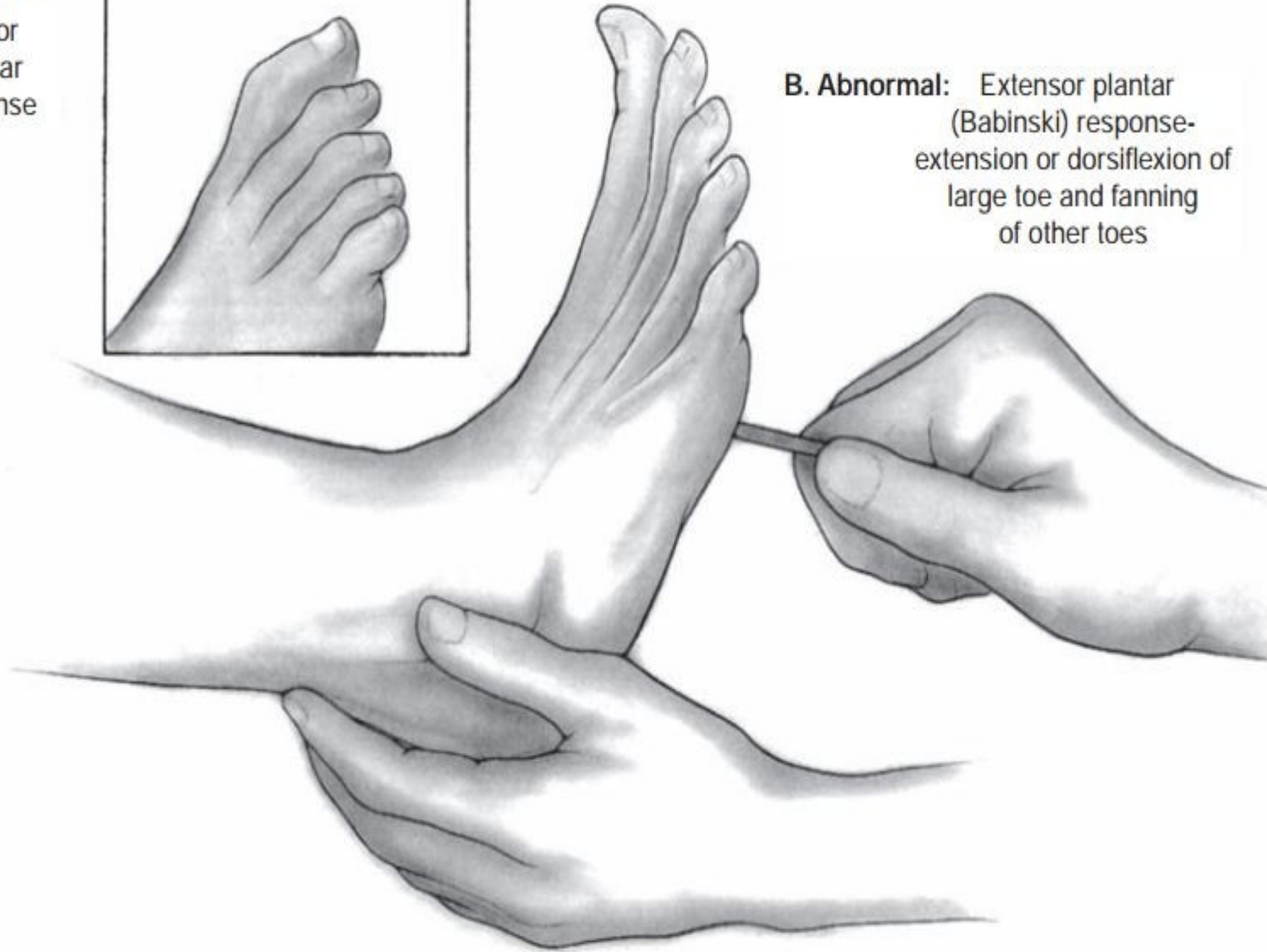
the foot.

Planter Reflex

A. Normal:
Flexor
plantar
response

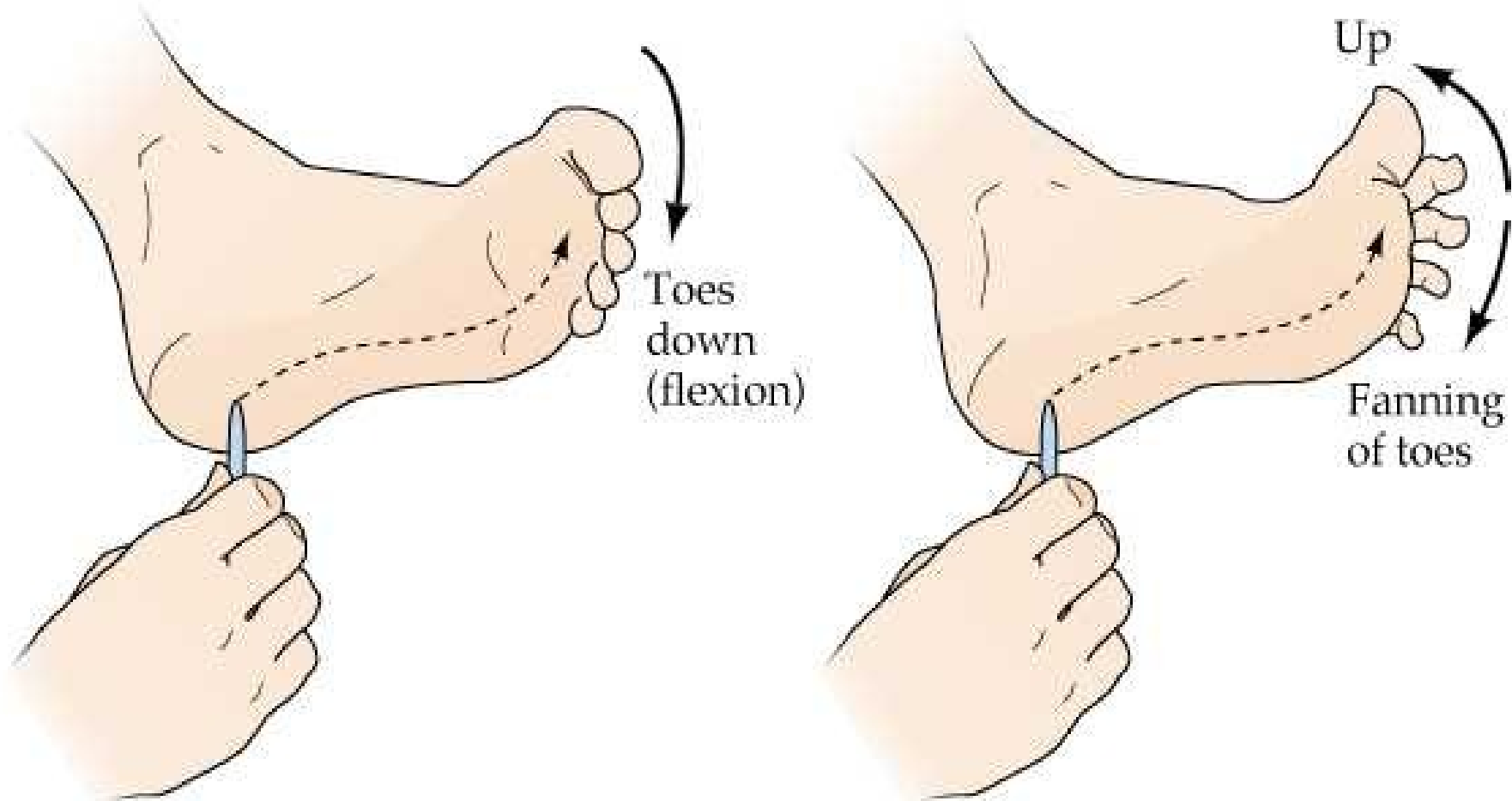


B. Abnormal: Extensor plantar
(Babinski) response-
extension or dorsiflexion of
large toe and fanning
of other toes



<http://www.medicinehack.com/2011/07/plantar-reflex-babinskis-sign.html> (Write the Name of the department)

Planter Reflex



Normal plantar response

Extensor plantar response
(Babinski sign)

<http://www.medicinehack.com/2011/07/plantar-reflex-babinskis-sign.html>

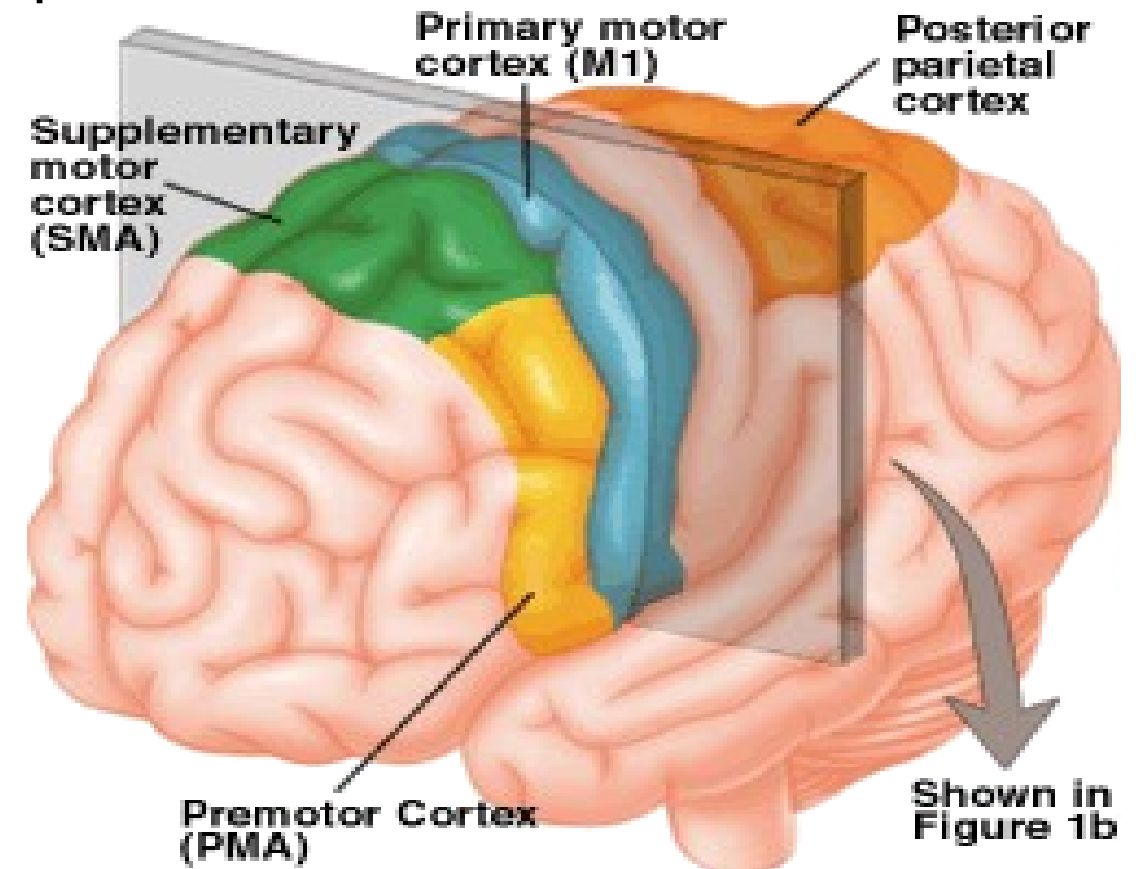
Motor area 6 (Premotor area)



Site: In front of motor area 4 on lateral aspect of frontal lobe.

Topographical representation:

Inverted
Crossed.



Motor area 6 (Premotor area)

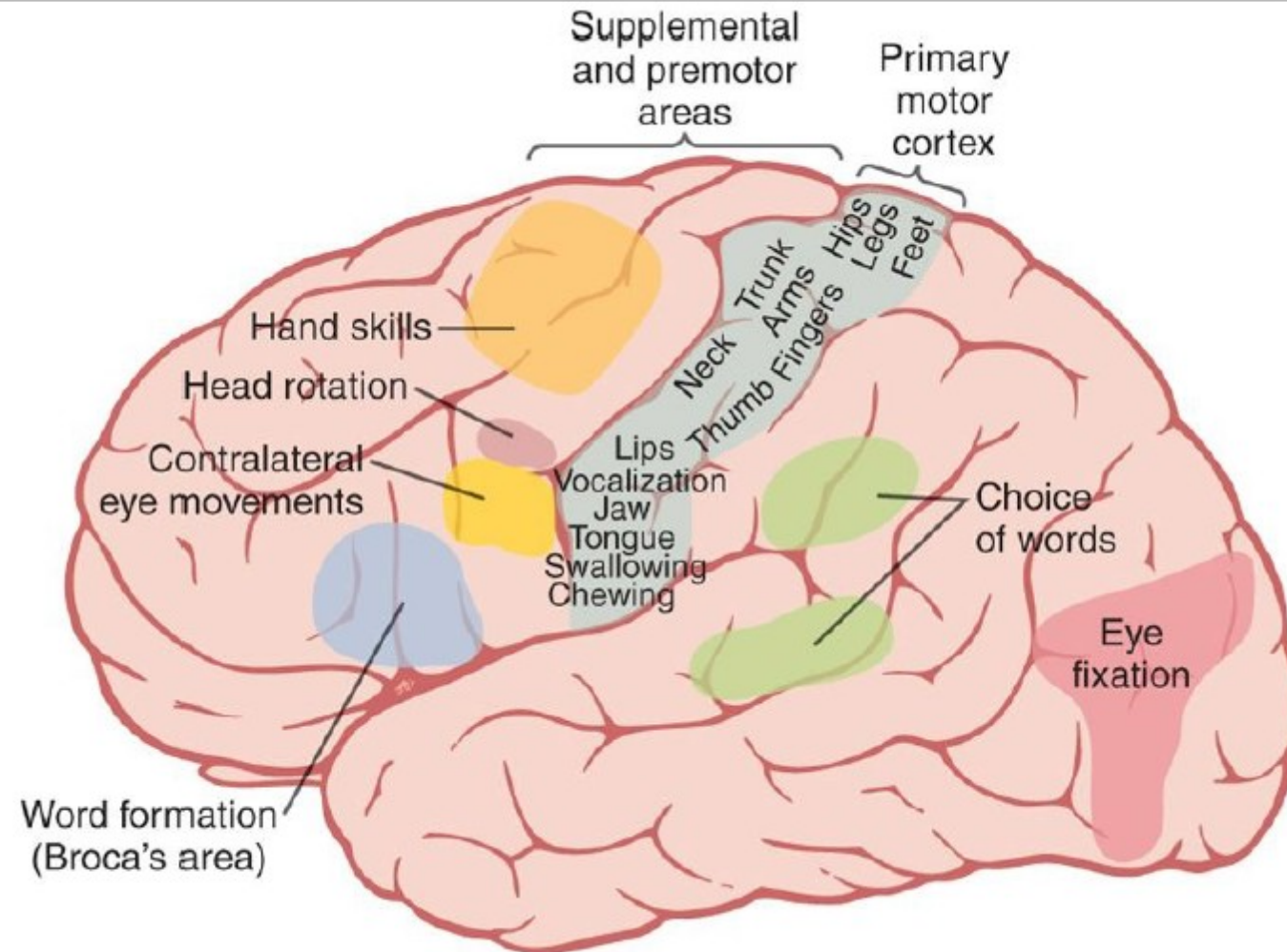


Grasp reflex



<https://www.parent24.com/Baby/Newborn/watch-the-palmar-grasp-reflex-20181121> [https://oth603competencysg.weebly.com/grasp-reflex.](https://oth603competencysg.weebly.com/grasp-reflex)

Specialized areas in the premotor cortex



Representation of the different muscles of the body in the motor cortex and location of other cortical areas responsible for specific types of motor movements. Guyton and Hall 13rd ed.

Specialized areas in the premotor cortex



important motor areas 4

Hand skills area	Head rotation area		
In the premotor area ant. to the 1ry motor cortex for the hands and fingers	In the premotor area immediately above area 8		
It controls complex skilled movements e.g. sharpening of pencil or drawing figures	It directs the head toward different objects.		
Aggraphia and motor apraxia	Inability to rotate the head toward different objects	telescoping tract from superior colliculus compensates and the reflex eye movements	<p> speak whole words or an occasional simple word such as ".no" or "yes" </p> <p>Motor Aphasia</p>



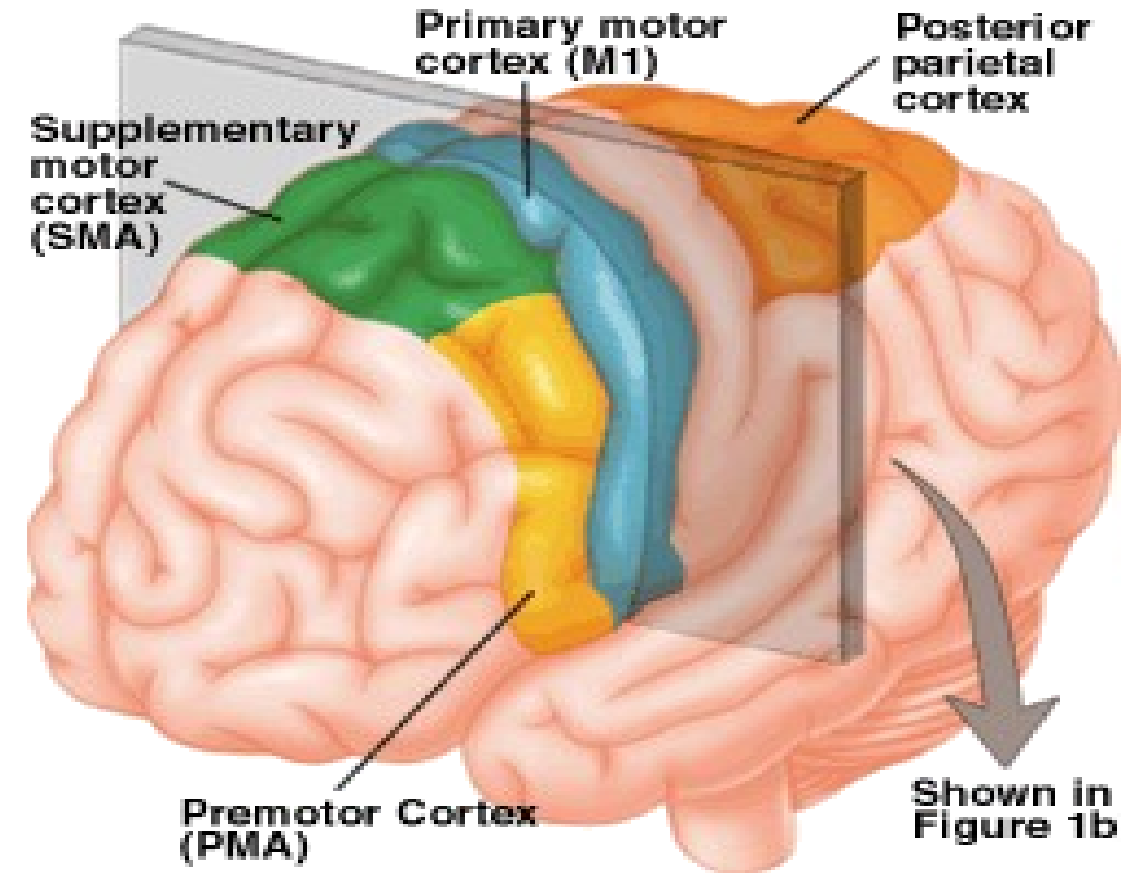
Supplementary motor area = medial area

Site: Medial surface of premotor cortex (superior to area 6). (on the medial side of the hemisphere)

Contains a map of the body; but it is less precise than in M1

Functions:

- 1- It supplements (helps) area 6 in the control of voluntary movements of the proximal parts of the body (gross movements) as a background for fine hand or feet movements.
- 2- It plays a role in planning of complex bilateral movements.



<https://brainconnection.brainhq.com/2013/03/05/the-anatomy-of-m>

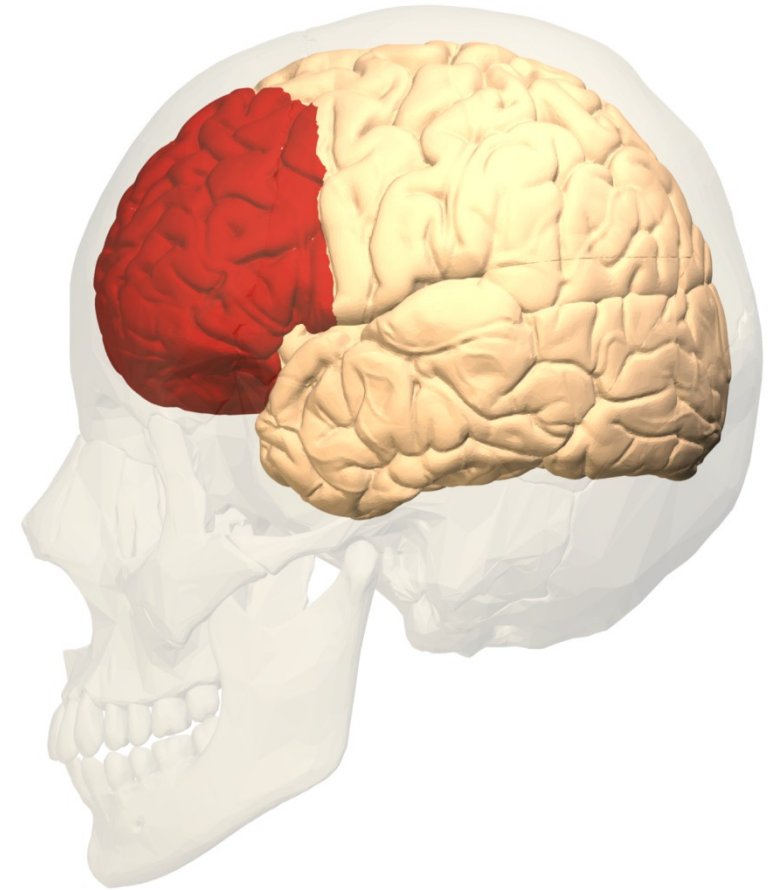
The prefrontal association area: Anterior association area

- **Site:**

It lies in frontal lobe anterior to premotor area.

- **Function:**

1. Elaboration of **thoughts** and **ideas**.
2. Because of its close association with the **motor cortex** it share in **planning** complex patterns and sequences of motor movements.
3. As it contains **Broca's Area** (motor speech center) it plans and stores programs of motor patterns for expressing individual words.
4. Due to its connection to **hippocampus** it is involved in recent memory.
5. Due to its connection with the **limbic system** it shares in the control of emotional behavior.



Cortical motor areas function and lesion (Quiz)



A 35-year-old man suffered a stroke that did not cause paralysis. However, he discovered that he was unable to perform complex learned movements. The region of the cerebral cortex most likely affected by the stroke was the:

- a. Precentral gyrus
- b. Postcentral gyrus
- c. Premotor cortex
- d. Temporal neocortex
- e. Prefrontal cortex

Cortical control over the motor function

MOTOR HIERARCHY



The control of movement by the central nervous system is a ***complicated process*** that **involves multiple regions of the brain**:

Generation of **idea** occurs in the
.prefrontal cortex

Awareness of the surrounding environment and position in space. This information is generated through **somatosensory, visual and auditory .sensory** inputs to the posterior parietal cortex

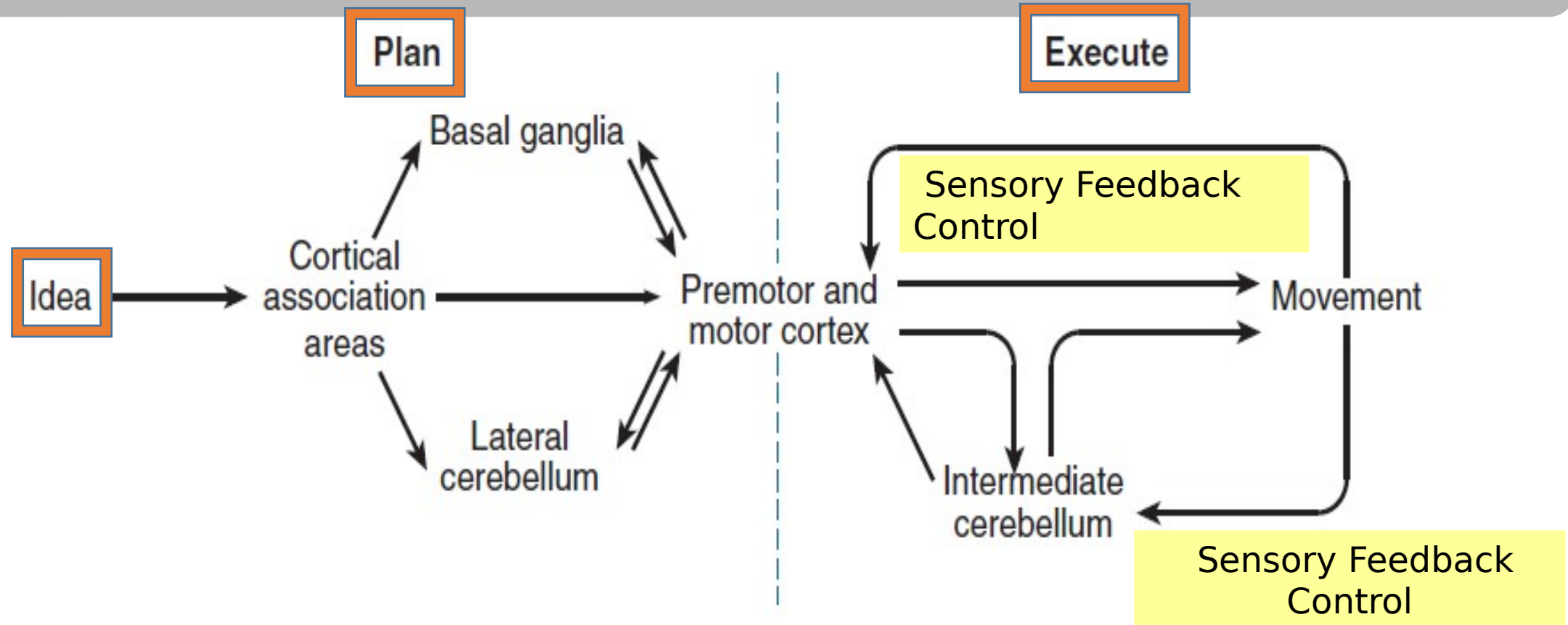
Motivation and past memories regulating the behavior takes place either
.rewarding or stopping the desire in the **limbic system**

Plan or program performed in the **basal ganglia, cerebellum, premotor .cortex** (PMC) and **supplementary motor areas** (SMA)

Execution of motor orders through the cortex is relayed via the corticospinal
.tracts and corticobulbar tracts to motor neurons

Cortical control over the motor function

MOTOR HIERARCHY



Control of voluntary movement: Commands for voluntary movement originate in cortical association areas. The cortex, basal ganglia, and cerebellum work cooperatively to plan movements. Movement executed by the cortex is relayed via the corticospinal tracts and corticobulbar tracts to motor neurons. The cerebellum provides feedback to adjust and smooth movement. Ganong 24th ed.

Cortical control over the motor function (Quiz)



- Which of the following is true as regard the normal sequence of firing neural activities of cortical motor areas before the start of the motor act?
 - a. Cerebellum → Premotor area → Prefrontal association area → Limbic system → Primary motor cortex.
 - b. Primary motor area → Basal ganglia → Premotor area → Prefrontal association area → Cerebellum.
 - c. Premotor area → Primary motor area → Limbic system → Sensory association areas → Prefrontal association area .
 - d. Supplementary motor area → Sensory association areas → Limbic System → Cerebellum → Primary motor area.
 - e. Prefrontal association areas → Sensory association areas → Limbic System → Cerebellum → Primary motor area.

Cortical PLASTICITY

- The motor cortex shows the same kind of plasticity as already described for the sensory cortex.
- **For example:**
 - The finger areas of the contralateral motor cortex enlarge as a pattern of rapid finger movement is learned with the fingers of one hand; this change is detectable at 1 week and maximal at 4 weeks.
 - When a limb is amputated its area of representation in the brain become not useless, but expansion of the neighboring area representing other body parts to this area occur.
 - When a small focal ischemic lesion is produced in the hand area of the motor cortex of monkeys, the hand area may reappear, with return of motor function, in an adjacent undamaged part of the cortex.
- Thus, the maps of the motor cortex are not immutable, and they change with experience.

Summary



- Skeletal muscle movement could be either voluntary (fine, gross) or involuntary movement (subconscious associated, reflex).
- Fine movement is initiated by area 4 and its programs were stored in area 6, so, area 4 lesion will lead to its paralysis, while lesion in area 6 will lead to apraxia.
- Gross movement is initiated by both area 4 and area 6, so, lesion in each of them will lead to paresis.
- Subconscious associated movement is controlled by area 6 and basal ganglia, so, lesion in each will lead to loss of this movement.
- Muscle reflexes are either superficial (e.g. withdrawal reflex) or deep (e.g. stretch reflex). As regard superficial reflexes area 4 lesion leads to loss of abdominal and cremasteric reflexes with partial positive Babinski sign. While area 6 lesion will lead to reappearance of grasp reflex and partial positive Babinski sign. For deep reflexes, area 4 lesion causes hypotonia and hyporeflexia. While area 6 lesion leads to hypertonia and hyperreflexia.
- Supplementary motor area lesion lead to inability to do complex bilateral movement in absence of paralysis.
- The normal sequence of firing from cortical areas before the start of motor act is as follow: prefrontal association area for elaboration of thoughts, sensory association areas (somatic, visual and auditory) for awareness of surroundings, limbic lobe for past history

SUGGESTED TEXTBOOKS



1. Ganong's review of medical physiology 25th edition
2. Gyuton and Hall 13th edition

A background image of a field of purple flowers, possibly globe amaranths, with a soft, out-of-focus green and yellow background. The flowers are in various stages of bloom, with some in sharp focus in the foreground and others blurred in the background.

THANK YOU